be in all his measurements on the same percentile grade. This latter method is based on a quite erroneous theory of the proportions of the body. Dr. Porter's method is also better than that based on single measurements, as it points out abnormal proportions, not simply abnormal size. It is necessary, however, to bear in mind the one restriction that many measurements are not closely correlated with stature, but have different correlations. This is the case with girth of chest, strength of squeeze and many others. Therefore their correlation to stature will not give more satisfactory results than the study of the single measurements alone. It will certainly be of great use to school hygiene to subject all children whose proportions are abnormal to a medical examination, but it will not be possible to determine by means of the measurements what individuals are retarded in growth and what are advanced, as Dr. Porter suggests, except in very exceptional cases. The correlation between any two measurements is so slight that a great many cases which are normal for one year are also quite normal for the preceding and following years at least. This is also shown by the fact which is apparently so contradictory, that children of a certain height are the heavier the older they are (according to Bowditch), but that also children of a certain weight are the taller the older they are.

Finally, I must say a word in regard to Dr. Porter's objection to the combination of measurements taken in different cities. It is, of course, true that the results in various cities depend upon the composition of the population and its geographical and social surroundings. If we knew all these factors and their influences it would be necessary to sub-divide the series of each city into numerous divisions. As we do not know the exact influence of these factors, we must endeavor to take as our basis a general curve, including as many individuals as possible of the same population but under a diversity of conditions and compare the curves determined by certain factors with them. It is, therefore, perfectly correct to compute the growth of American children from data collected in various cities, provided each city is given its proper weight according to the number of children measured. The more cities and villages are included in such a combination, the more nearly we shall get the curve representing the growth of the American child. By comparing the general curve with the ones obtained in different cities we can investigate the causes which produce the difference between the individual curves and the general curve. We know that nationality, occupation, social status have a considerable influence. I have found that first-born children exceed later-born children in size. The effect of all these causes can be studied by comparing the individuals representing each group of factors with the general population.

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## *LABORATORY TEACHING OF LARGE CLASSES IN BOTANY.**

The great increase in the size of the classes in Elementary Botany during late years in Harvard College has forced their teachers to the development of some system for their efficient and economical management in the Laboratory. Under the guidance of Professor Goodale there has been worked out the plan upon which are based the recommendations made in this paper; indeed, what I have to say is little more than a description of the system in use there during the last year I was connected with it, *i. e.*, 1892–'93. My observations are, therefore, based not upon theory alone, but upon the results of trial and selection.

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The conditions which had to be faced were these: A class, numbering towards, and in one year over, 200 men, and likely in the future further to increase, composed of beginners ignorant of how to study *things*, comes in for a course in General Botany, extending from the middle of February to the first of June, in all some fifteen weeks. There are two regular weekly lectures. The Laboratory work cannot for academical reasons exceed an average of four hours per week, and for practical reasons it must be confined to the hours 11–1 and 2–5 Tuesday, the same hours on Thursday, and 9–1 Saturday, *i. e.*, only 14 hours in the week are available. The normal seating capacity of the Laboratory is 75, but the supply of dissecting microscopes and boxes for students' utensils, books, etc., is enough for over three-fourths of the class.

I give thus fully a statement of the conditions at Harvard, because they illustrate in kind, though perhaps in unusually favorable degree, the difficulties which in more or less modified form must be faced in all large colleges providing elementary laboratory instruction, and to which an efficient system of laboratory management must be adapted. These conditions may be classified for purposes of discussion as follows:

1. The classes are too large for individual teaching by the instructor.

2. Laboratory hours must be adjusted to other academic work, to insufficient accommodations and sometimes to yet other considerations.

3. Many students of diverse attainments must be taught how to work and to think scientifically, and must be kept progressing together through the stages of a logically-graded course.

4. Large quantities of special material must be provided at an unfavorable season.

I have placed first what all admit to be the greatest drawback to large laboratory classes, but one which seems inseparable from our unwieldy colleges, *i. e.*, the impossibility of individual knowledge of and contact with his students by the instructor. That this kind of teaching, this diagnosis of each case and fitting of proper treatment to it, is the only good kind, and that no development of methods or systems, or of leadership of the whole class by one man, can replace it, is pedagogically so axiomatic that the instructor should here take his stand squarely and insist that his students shall have it, if not from him directly, then from competent assistants trained by him. I regard this as the first great essential in the laboratory teaching of large classes—competent assistants.

The source of supply of such assistants is not far to seek; they should come from amongst the advanced students who have been through the course and who intend to make teaching a profession. Any college with elementary courses large enough to need such a system as we are discussing must have advanced students in proportional numbers, and skillful management of the real advantages of the position should give the instructor his choice from among them. In Harvard College the supply has always exceeded the demand; the prestige, experience and money attaching to the positions make them attractive to the best men.

The assistants having been thus selected, it is essential to place each in full charge of a section which he keeps without change to the end of the term, in order that he may come to know well and teach well each individual. These sections should never exceed thirty men, and twenty-five is a much better, and twenty the best number. The instructor himself will, of course, visit the laboratory constantly, but he will do far better to go about among the men generally than to take a section himself. Moreover, great freedom should be allowed to the judgment of each assistant in the details of his

teaching. There must be, to be sure, a uniform plan of study for the course, but the carrying-out of the plan in details should be left to the assistant, who should be held responsible for his results rather than his methods. It is very desirable, or perhaps, I should say, necessary, to hold weekly meetings of the assistants at which the coming laboratory topics are discussed, uniform ways of treating difficult or morphologically debatable questions agreed upon, and pedagogic advice given, the latter, as I have found, always eagerly received and acted upon. In this way, in conjunction with the weekly guides to be mentioned below, all desirable uniformity of treatment can be secured.

It is necessary, and indeed, good policy as well, to pay the assistants; the amount will vary according to the general scale of expenditure in vogue in the particular college. One dollar an hour may be considered fair, perhaps the maximum that it is needful to pay.

Let us consider secondly how conflicting hours may be adjusted to insufficient accommodations, and to the need of bringing each man always under the same assistant. The solution of this often appalling problem can be found only in this: the instructor must claim for his Laboratory work equal rank with any other college exercises, make the choice of hours, or rather sections, as wide as possible, and require students to work exactly in these sections or else remain out of the course. The size of the sections must be limited partly by the number an assistant can manage, partly by the seating accommodation of the laboratory. Thus a room of fifty to sixty seats can accommodate two sections at once. The hours should be arranged so as to give at least two hours of consecutive time; the best arrangement for a four-hour-a-week course is to have each section meet in two-hour periods at the same hours on two different days. Thus a section meeting 11–1 Tuesday would meet 11–1 Thursday. No student should be allowed to break hours and come in different sections if it can possibly be avoided. To arrange the students in sections, each should be asked to hand in, at the opening of the work, his preference and his second choice. The great majority can be assigned to their preference, only a few, selectable by lot, need to be placed in their second choice in order to adjust the sizes of the sections. In order to prevent all confusion, we have found it very useful to give each student a card stating the number of his section, of his seat, of his microscope, of his box and the name of the assistant, and to check off for each section on blue-print plans of the laboratory and lists of instruments, etc., the numbers as assigned. By this plan successive sections may use the same seats and instruments without confusion and each come always under its own assistant.

We have next to notice how the labor and confusion of getting the sections to work may be minimized and the time of the assistants economized for the higher grades of their teaching work, and how the sections may be kept progressing uniformly. The beginner (and for that matter the most advanced of students), when a new topic is placed before him, has no idea of what he is to study about it, of what is important and what is not, of the nomenclature he is to employ. The questions "what am I to do with it?" "what do you want me to do next?" dreadful as they sound, are yet natural enough. If these questions can be answered for each student without reference to the assistant it is an immense gain, and they can be answered by a printed guide or synopsis of the week's work supplied each week to each student. These should be arranged upon the approved plan in use in the many excellent laboratory manuals, *i. e.*, they should indicate the points which it

is needful to study, suggest some idea of their relative importance, give needed bits of information now and then, and in general supply just enough data to allow the student to work by himself to correct conclusions. But an ordinary laboratory manual is not sufficient, for a great value of these weekly guides is that they fit the exact material to be used, the state of advancement of the class, and the logical course laid out by the instructor, which cannot be the same as that of anybody else's manual. These guides may also be made to supply botanical terms, always upon the good pedagogic principle of making the student feel the need of a term before supplying it, and then offering it not as a term with a definition, but as a definition or description which can be expressed in a single word. The effect of these guides upon the order and rapidity of work is remarkably great, and they enable one assistant to teach a much larger section than is possible without them.

It is also of very great value to the laboratory work to have the lectures accompany, and actually, as they do theoretically, supplement it. This is practically possible, though perhaps not always convenient. The most logical course (to be briefly described immediately) that I have been able to develop in my few years' teaching does allow the lectures to keep with and supplement the laboratory work throughout the term. Laboratory study must always be the study of a few type forms; the correlation of the data thus gained, their bearing upon general principles and their relation to the science as a whole must be the function of the lecture, and this is the better performed when the latter follows as closely as possible upon the former and while it is still fresh in mind. A few minutes at the beginning of each lecture devoted specially to the topics of the laboratory work just past, and its relation to what is to come, has been found to be very profitable.

We come finally to our fourth and last problem, how can good materials be provided in the winter to such large classes? A college which has abundant greenhouses hardly needs to ask this question. What remarkable results may be obtained in providing large quantities of material from small space is shown by Mr. B. M. Watson's work at the Bussey Institution in supplying material to the classes at Harvard. For those less fortunately situated, its solution is to be found in so arranging the course that materials available in the markets or easily grown, come first, and are gradually replaced by out-door materials as the season advances. Happily the most logical plan of treatment for a general course in Botany lends itself exactly to this procedure. Experience has shown that with elementary classes it is desirable to consider plant life as a cycle, which may best be broken for study at the seed. If now the structure and morphology of the seed be the first topic in both Laboratory and Lectures, and its development into the young plant the second, and if then the plant-organs leaf, root, stem, flower and fruit be treated in succession, we are in both brought back to the starting point, the seed. If, moreover, in the lectures, the full biology and physiology of each organ be considered along with its anatomy and morphology and as determining these, then are the topics not only treated in the most logical and instructive fashion, but the lectures and laboratory work may be kept together, the one truly supplementing the other; and the topics are taken up in the order which allows material best obtainable in winter to come first, gradually giving place to that which the spring offers. The seed, always obtainable, comes first, then follow germinating embryos and young plants easy to grow in wardian cases in class rooms or at very small cost in the nearest greenhouse. Leaves may be obtained from the same greenhouse, from

evergreen shrubs out of doors or even bought in the markets, as celery, cabbage, etc. Roots may likewise come from the markets, stems and buds abundantly from the trees out of doors, and towards spring the latter may be forced to open in warm rooms. Far too little use is made of these easily obtained materials. By the time the vegetative organs have been studied the first Apetalæ will be in bloom, and if the students have been properly taught to use eyes and hands the Apetalæ will present no difficulties; later come other wild flowers, and all is easy.

Allow me, in conclusion, to sum up the points of this paper. In the laboratory teaching of large classes, the first essential is a recognition of the fact that nothing can replace individualism in teaching and that a sufficient number of assistants should be employed. These assistants must be intending teachers, given some pedagogic instruction, supplied with a uniform plan of work, but left very free in the details of their modes of reaching the students. Classes should be divided into sections with fixed hours and containing not more than thirty men, over each of which one assistant has entire charge until the end of the term. As an aid to uniformity of plan and to answer the innumerable legitimate questions which arise in laboratory work, as well as to supply technical nomenclature, weekly printed guides, fitted to the exact work being done, should be supplied to each student. Lectures and laboratory work should be kept together and follow such a course that the vegetative organs upon which material is at all times available should be studied in the winter, and the reproductive organs in the spring or summer.

So much for a general plan; each teacher must vary it in adaptation to his own needs.

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*MAGNETISM AND THE WEATHER.*

Much time has been devoted to the study of magnetic and meteorologic observations with the hope of establishing a definite connection between the two. The results thus far have been almost entirely negative, although a connection has been found with auroras, and the diurnal range of air pressure is now believed to be a thermo-electric phenomenon, allied to the diurnal range in the swings of the magnetic needle. There are certain well established facts that have been ascertained regarding magnetism that almost always stand at the base of all such investigations, although it is admitted that magnetic phenomena are extremely complex, and those of the weather are far more so.

1. The three principal magnetic conditions or fluctuations are as follows: (a) The diurnal change due to some combined solar and terrestrial action. (b) Magnetic storms, which are peculiar and sharp disturbances, generally originating in the sun. These often occur at three or four successive rotations of the sun.

(c.) A gradual change in magnetism from one day to the next. These are quite singular, and have been studied more than any other conditions in the hope of establishing some relation with our weather.

2. In studies of magnetism strenuous and long continued efforts have been made to establish a regular recurring period depending upon the rotation of the sun. It is easy to see that if there were such regular period its discovery would be of the profoundest significance. The results of such studies, however, have been far from satisfactory. It is known that sunspots have a different period of rotation, according as they are near or far from the equator, and this fact is enough to show the extremely dubious nature of an attempt to fix on any definite period for recurring solar effects. It is not at all surprising that more than a